

# STUDY ON THE PREPARATION OF SODIUM CHROMATE FROM LOW GRADE CHROMITE OF MUSLIMBAGH PAKISTAN

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**ABSTRACT:** A significant and cheaper chemical compound, Sodium chromate having the formula  $\text{Na}_2\text{CrO}_4$  was prepared from low grade chromite of Muslimbagh area. Sodium chromate has diversity in the industrial and laboratory applications. Head sample was prepared by crushing, pulverizing and sieving for the analysis of chromite ore. Beneficiation of low grade chromite ore was carried out to get 45 - 48%  $\text{Cr}_2\text{O}_3$  (chromite concentrate) by Spiral and Tabling techniques. 90% yield of sodium chromate was obtained by roasting and leaching method. The optimum reaction parameters were temperature ( $1150^\circ\text{C}$ ), time (3 hours) with composition of raw material, chromite concentrate (48.7%), soda ash (17.9%) and lime (33.4%) respectively.

**Keywords:** Sodium chromate, Low grade chromite ore, Muslimbagh area

## 1. INTRODUCTION

A chemical compound sodium chromate with the formula  $\text{Na}_2\text{CrO}_4$  and yellow crystals is a strong oxidizer. Sodium chromate is valuable for direct application and production of other secondary compounds. Sodium chromate is widely used in leather tanning, medicines, photography and manufacturing of pigments for dyes and textile processing. Sodium chromate is also used in rocket grenades and tracer bullets. United States army uses sodium chromate impregnated uniforms, blankets and yellow lines on roads are marked by using sodium chromate.

Ahmad Z. reported chromite ores in Pakistan at Muslimbagh, Malakand and Dir. Chromite ores of Muslimbagh were considered high in chromic oxide contents ( $\text{Cr}_2\text{O}_3$  34%) as compared to Malakand chromite ores with ( $\text{Cr}_2\text{O}_3$  30%). [1]

Agrawal B. C. and Jain S. P. in 1963 explained that chrome compound (sodium chromate) can only be synthesized with 45 - 48%  $\text{Cr}_2\text{O}_3$  contents. Beneficiation was carried out to upgrade upto 45 - 48%  $\text{Cr}_2\text{O}_3$  of the low grade chromite ores. [2]

Baker in 1975 synthesis of sodium chromate was carried out in England from equimolar atmosphere of  $\text{Na}_2\text{O}$  and  $\text{Cr}_2\text{O}_3$  and identified by x-ray diffraction patterns. [3]

Pavlov V. M. in 1975 produced sodium chromate from sintered mass containing chromite concentrate and  $\text{Na}_2\text{CO}_3$  in 4:1 weight ratio. The sintered mass was roasted and leached with water and the solution was filtered to obtain sodium chromate. [4]

Banerjee [5] roasted chromite ore of 100-150 mesh with  $\text{Na}_2\text{SO}_4$  and lime stone at  $800 - 1000^\circ\text{C}$  to prepare sodium chromate. Dry roasted material was leached with water and was filtered. The residue was reacted with  $\text{H}_2\text{SO}_4$  to increase sodium chromate recovery.

Wanning in 1989 synthesized sodium chromate by oxidation mechanism, in which  $\text{Cr}_2\text{O}_3$  was roasted with  $\text{Na}_2\text{CO}_3$ . The evolution of  $\text{CO}_2$  and composition of the roasted product was studied. The synthesis of sodium chromate was identified at  $900 - 1000^\circ\text{C}$ . [6]

Shigeno studied  $\text{Cr}_2\text{O}_3$  in a chromite soda charge by the oxidation pathway at  $900 - 1050^\circ\text{C}$  for the synthesis of sodium chromate by using chromite ores of various grades. [7]

In 2004, sodium chromate was prepared by Jeong *et. al* in Korea by reacting chromite concentrate with liquid  $\text{NaOH}$  at  $70 - 80^\circ\text{C}$ .  $\text{Na}_2\text{O}$  was used as catalyst. [8]

Tathavadkar V. D. produced sodium chromate by the soda ash roasting of chromite ore in 2001. [9]

Alkali and alkaline earth chromate by time of flight laser microprobe mass spectrometry and fourier transform ion cyclotron resonance mass spectrometry were studied by Frederic A. in 2000. [10]

## 2. MATERIAL AND METHODS

The head sample of the ore was prepared by crushing the lumps of ore in the size range 4 - 12 inches in a jaw crusher and then crushed in a roll crusher to a size of 4 meshes. The sample prepared was used for chemical analysis and further processing work.

### 2.1 Chemical Analysis of Head Sample

Table – 1: Analysis of Head Sample

Constituents	%age purity
$\text{Cr}_2\text{O}_3$	48.00
$\text{Fe}_2\text{O}_3$	18.20
$\text{SiO}_2$	06.38
$\text{Al}_2\text{O}_3$	16.25
$\text{MgO}$	10.73
Weight loss	00.52

Gravimetric and titrimetric methods were used to determine the presence of different constituents of chromite ore. Moisture was removed by placing a small amount of head sample in an oven for 2-3 hour. 0.5g chromite ore fused with 8-10g  $\text{Na}_2\text{O}_2$  at  $700^\circ\text{C}$  was dissolved in hot water, cooled, filtered and made the volume of filtrate upto 250mL (solution A) for the determination of  $\text{Cr}_2\text{O}_3$ ,  $\text{Al}_2\text{O}_3$  and  $\text{SiO}_2$ . The residue was dissolved in diluted  $\text{HCl}$  and volume was made upto 250mL (solution B), which was used for the determination of  $\text{Fe}_2\text{O}_3$  and  $\text{MgO}$ .

**Table – 2: Analysis of Head Sample**

Constituents	%age Purity
Cr <sub>2</sub> O <sub>3</sub>	34.92
Fe <sub>2</sub> O <sub>3</sub>	15.95
SiO <sub>2</sub>	17.30
Al <sub>2</sub> O <sub>3</sub>	13.00
MgO	11.20
Weight Loss	07.00
Others	00.50

## 2.2 Beneficiation

The Muslimbagh Chromite Ore was concentrated prior to its use for the synthesis of sodium chromate as it was of low grade (34%). Humphrey's Spirals and Wilfley's Table methods were employed for chromite ore beneficiation to get chromite concentrate (45 - 48%).

## 2.3 Chemical Analysis of the Chromite Concentrate

The grade of chromite concentrate was determined through its chemical analysis. The same procedure was adopted for the chemical analysis of chromite concentrate that were used for the chemical analysis of head sample of chromite ore.

## 2.4 Synthesis of Sodium Chromate

### 2.4.1 Material

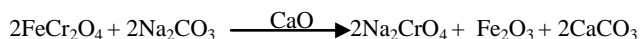
1. Chromite concentrate (Cr<sub>2</sub>O<sub>3</sub> 48.7%)
2. Soda ash (Na<sub>2</sub>CO<sub>3</sub>)
3. Calcium oxide (CaO)

### 2.4.2 Methods

Preparation of sodium chromate (Na<sub>2</sub>CrO<sub>4</sub>) from chromite ore was performed through the roasting and leaching methods.

### 2.4.3 Roasting and Leaching

Chromite Concentrate, soda ash (Na<sub>2</sub>CO<sub>3</sub>) and calcium oxide (CaO) were mixed in different ratios. The mixture was moistened with water and pelletized upto 3/8 sized pellets. The pelletized mixture was roasted in gas fired furnace. Dark green pellets obtained after roasting and cooling were leached with water and filtered. The filtrate was treated with sodium dichromate to remove Al<sub>2</sub>O<sub>3</sub> which increased the purity. H<sub>2</sub>SO<sub>4</sub> was added into the solution to convert NaHSO<sub>4</sub> into Na<sub>2</sub>SO<sub>4</sub> in acidification tank and gain filtered and concentrated in a concentration tank. Yellow crystals of sodium chromate were obtained and dried in tray drier.



### 2.4.4 Precipitation of Sodium Chromate

The alumina free sodium chromate filtrate was evaporated to produce sodium chromate crystals. The precipitates were washed to get sodium chromate free of sodium carbonate and dried in an oven at 110 - 120°C.

### 2.4.5 Analysis of Sodium Chromate

Moisture, total sodium chromate content and trace elements, such as Fe, Cr, Na were detected. The %age purity of sodium chromate was 90% and grade was commercial.

## 3 RESULTS AND DISCUSSION

### 3.1 Effect of Temperature

The effect of temperature was observed by changing

temperature at constant time and composition of the mixture. The low yield at 1200°C was due to the formation of calcium chromate that was soluble in H<sub>2</sub>SO<sub>4</sub>. Calcium chromate was formed when chromite concentrate was heated with excess of calcium oxide above 1100°C.

### 3.2 Effect of Time

Maximum yield of sodium chromate was obtained in three hours keeping the constant composition of the reaction mixture (soda ash 17.9%, chromite concentrate 48.7%, calcium oxide 33.4%) and constant temperature (1150°C). The reason of low yield at four hours was that the sodium chromate formed was decomposed into acid soluble calcium chromic chromate.

### 3.3 Effect of Composition

Maximum yield, such as 90% of sodium chromate was obtained by using soda ash 17.9%, Chromite concentrate 48.7% and calcium oxide 33.4%. In order to explain the reduction in conversion, five compositions were heated for three hours at 1150°C.

### 3.4 Effect of Removal of Alumina (Al<sub>2</sub>O<sub>3</sub>)

The alumina present in the sodium chromate solution was removed by adding sodium dichromate solution by maintaining the pH at about 9, sodium dichromate caused the hydrated alumina to crystallize. Alumina was separated by filtration and washed with water.

### 3.5 Effect of Addition of Sulphuric Acid

The reaction between chromite concentrate, soda ash and limestone was carried out at temperatures 1100°C and 1150°C respectively. The yield of sodium chromate at 1100°C and 1150°C was 80% and 85% respectively. The percentage purity of sodium chromate was uplifted upto 90% when H<sub>2</sub>SO<sub>4</sub> was added to the reaction mixture in the acidification tank to convert NaHSO<sub>4</sub> into Na<sub>2</sub>SO<sub>4</sub> in the reaction mixture and the conversion under similar conditions of temperature (1150°C) and time three hours.

## 4 CONCLUSIONS

The main achievement of this research is the synthesis of sodium chromate, by using local raw material. In Pakistan, chrome based chemicals are produced on a very limited scale. The main source is chromite ore in Pakistan for the production of chrome based chemicals.

However, there are number of chromite ores in different areas of Pakistan, but indigenous chromite ore of Muslimbagh area was used for this purpose because it was simple in composition and easy to upgrade. Chromite ores of Muslimbagh area are considered of commercial significance for the synthesis of sodium chromate.

As chromite ores of Muslimbagh area are low grade (34% Cr<sub>2</sub>O<sub>3</sub>), therefore beneficiation was carried out to obtain required grade (45 - 48%). A good yield of sodium chromate was obtained by roasting and leaching. Chromite concentrate was roasted with soda ash and calcium oxide. Dark green pellets obtained were leached with water and filtered. The filtrate was evaporated to obtain and analyze yellow crystals of sodium chromate.

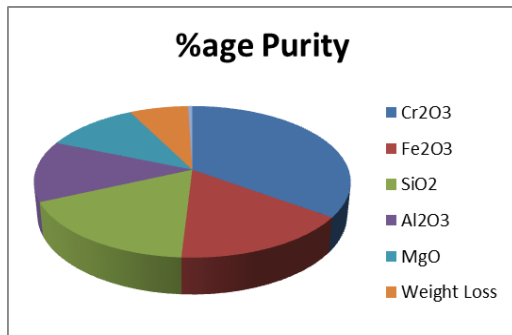


Figure – 1: Analysis of Head Sample

The optimized temperature, time and composition of raw material used for the preparation of sodium chromate were 1150°C, three hours and chromite concentrate 48.7%, soda ash 17.9% and lime 33.4% respectively. Therefore, it was concluded that chrome based chemicals such as sodium chromate can be prepared by using Pakistan's (Muslimbagh) chromite ore as local raw material which will be economical and low cost.

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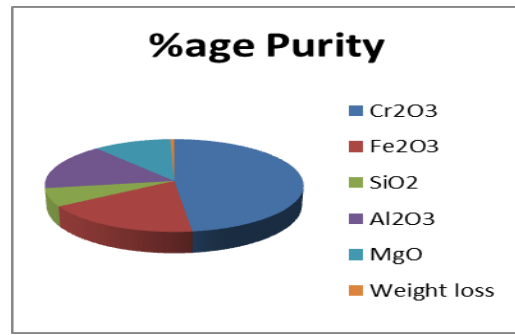


Figure – 2: Composition of Chromite Concentrate

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